MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

ECT2036 – CIRCUITS AND SIGNALS

(TE, RE)

26 OCTOBER 2018
9:00 am – 11:00 am
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 8 pages including cover page with 4 Questions only.

2. Attempt **ALL** the questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

4. Appendix is provided after the question pages.

Question 1

a) From the electric circuit in Figure Q1(a), draw its network graph as tree and co-tree, and then determine the *f-cutset* and *f-loop* matrices. [10 marks]

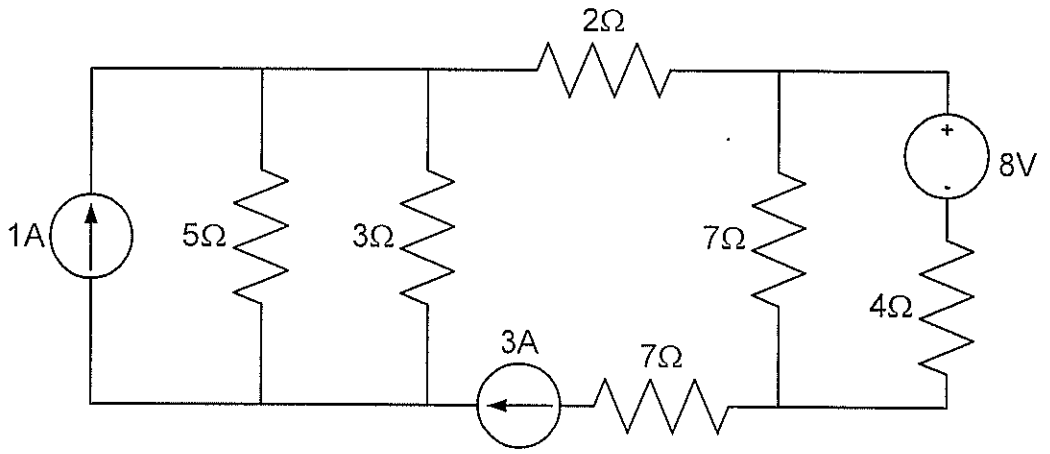

Figure Q1(a)

b) What are the *even* and *odd* parts of the function, $g(t) = 4\cos(3\pi t)$? [4 marks]

c) Determine whether the function, $f(t)$ is a *power* signal or an *energy* signal:

$$f(t) = \begin{cases} 0 & : t < 0 \\ e^{-t/T} & : t \geq 0 \end{cases}$$

T is a real number such that $0 < T < \infty$. [4 marks]

d) Perform discrete-time convolution mathematically at $n = 5$ for:

$f_1[n] = (-1)^n \{ u[n] + u[n-1] \}$;

$f_2[n] = n \{ \delta[n] + 2u[n-1] - u[n-2] \}$ [7 marks]

Continued...

Question 2

a) Find the Laplace transform of $f(t) = 1 - 2e^{-2t}$. [4 marks]

b) Solve for the *initial* and *final* values of $F(s) = \dfrac{5s}{(s+4)(s+3)}$ [4 marks]

c) The switch in Figure Q2 has been open for a long time and is closed at t = 0.
   i. Draw its equivalent s-domain circuit. [5 marks]
   ii. Assuming zero-initial condition, determine $v(s)$ in term of R, L and C. [7 marks]
   iii. Then solve for $v(t)$ if I = 1mA, L = 2H, R = 1.5kΩ and C = 1/6 μF. [5 marks]

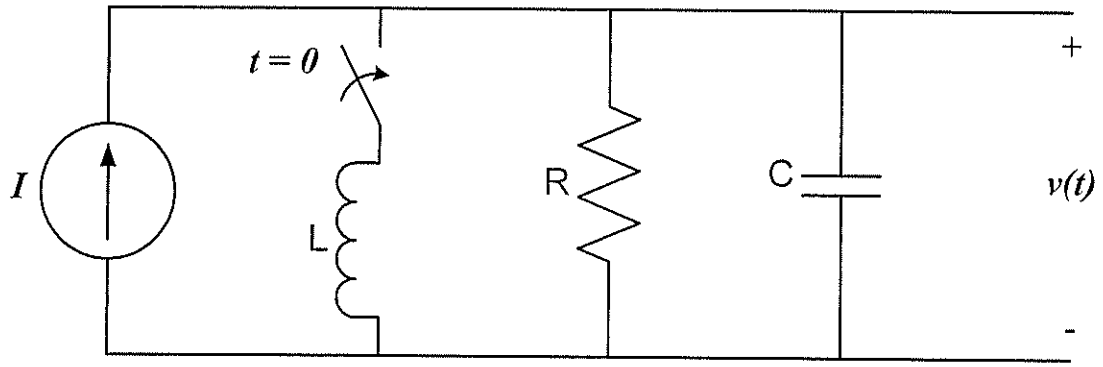

Figure Q2

Continued...

Question 3

a) Referring to the two-port network in Figure Q3, derive
   i. I_1 in terms of V_S, R_S, R_1, R_2 and R_L [1 mark]
   ii. I_2 in terms of V_2 and R_L [1 mark]
   iii. V_1 in terms of V_S, R_S, R_1, R_2 and R_L [2 marks]
   iv. V_2 in terms of V_S, R_S, R_1, R_2 and R_L [2 marks]

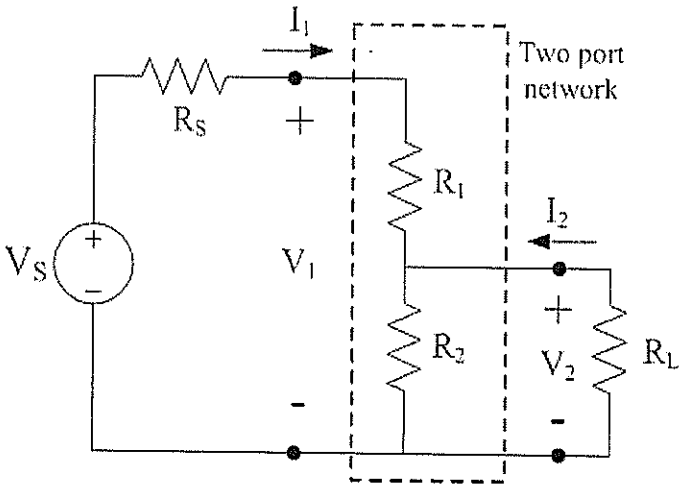

Figure Q3(a)

b) Using equations obtained in part (a), solve for the
   i. open-circuit input impedance, z_{11} [2 marks]
   ii. open-circuit voltage gain, a [2 marks]
   iii. negative short-circuit current gain, d [2 marks]
   where $R_S = R_1 = R_2 = R_L = 5\Omega$

c) The circuit in Figure Q3(b) that has two input sources, v_1 and v_2. Determine the *state variable models* if i_o is the output.

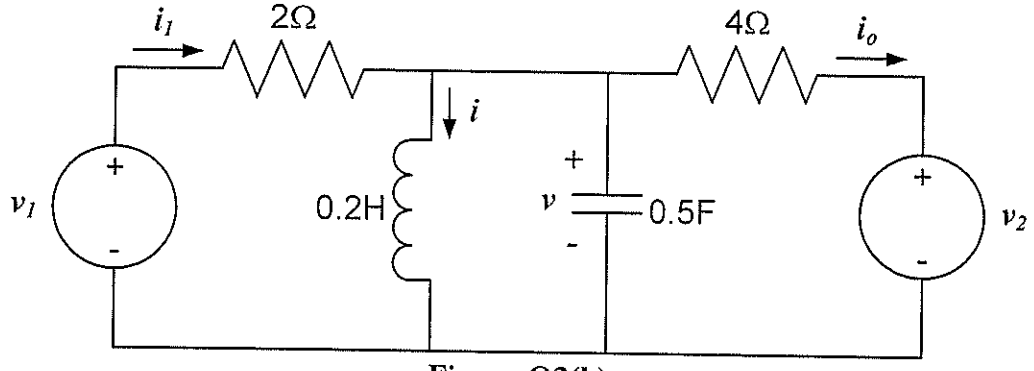

Figure Q3(b)

[13 marks]

Continued...

Question 4

a) Given the impedance function, $Z(s)=\frac{s^3+4s}{s^2+2}$, synthesize its

i. First Cauer form [7 marks]
ii. Second Cauer form [9 marks]
(Write out their respective final Z(s) equations and draw their equivalent networks)

b) Convert the lowpass filter in Figure Q4 to a highpass filter by performing *frequency transformation* and *impedance denormalization* given that the cut-off frequency, ω_o is 10^6 rad/s and load impedance is 2kΩ.
Draw the highpass filter circuit. [9 marks]

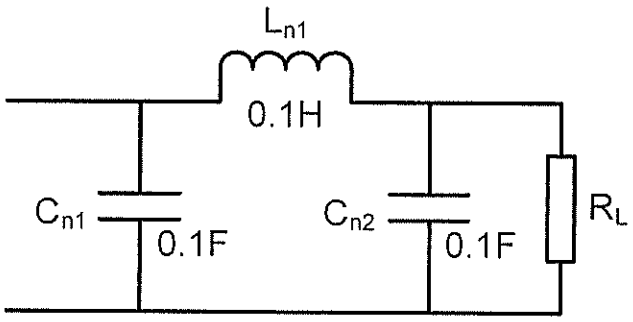

Figure Q4

Continued . . .

APPENDIXES

Chapter 1:

Nodal Analysis	**Mesh Analysis**
1. $Y_N = AYA^T$	1. $Z_M = BZB^T$
2. $e_{\text{Node}} = -Y_N^{-1}A(I+YE)$	2. $i_{\text{Mesh}} = Z_M^{-1}B(E+ZI)$
3. $e = A^T e_{\text{Node}}$	3. $i = B^T i_{\text{Mesh}}$
4. $i = Ye + (I+YE)$	4. $e = Zi - (E+ZI)$
Fundamental Cutset Analysis	**Fundamental Loop Analysis**
1. $Y_C = CYC^T$	1. $Z_L = DZD^T$
2. $e_{\text{Twig}} = -Y_C^{-1}C(I+YE)$	2. $i_{\text{Link}} = Z_L^{-1}D(E+ZI)$
3. $e = C^T e_{\text{Twig}}$	3. $i = D^T i_{\text{Link}}$
4. $i = Ye + (I+YE)$	4. $e = Zi - (E+ZI)$

Chapter 2:

Even signal: $f(t) = f(-t)$ or $f[n] = f[-n]$

Odd signal: $f(t) = -f(-t)$ or $f[n] = -f[-n]$

Energy content: $E = \lim_{T\to\infty} \int_{-T}^{T} f^2(t)dt$ or $E = \lim_{N\to\infty} \sum_{n=-N}^{N-1} f^2[n]$

Power content: $P = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} f^2(t)dt$ or $P = \lim_{N\to\infty} \frac{1}{2N} \sum_{n=-N}^{N-1} f^2[n]$

Chapter 3: Laplace transform pairs

No.	*t*-domain function	*s*-domain transform
1.	$\delta(t)$	1
2.	$u(t)$	$1/s$
3.	$tu(t)$	$1/s^2$
4.	t^n	$\frac{n!}{s^{n+1}}$
5.	e^{-kt}	$\frac{1}{s+k}$
6.	$t^n e^{-kt}$	$\frac{n!}{(s+k)^{n+1}}$

7.	$\sin\omega t$	$\frac{\omega}{s^2+\omega^2}$
8.	$\cos\omega t$	$\frac{s}{s^2+\omega^2}$
9.	$e^{-kt}\sin\omega t$	$\frac{\omega}{(s+k)^2+\omega^2}$
10.	$e^{-kt}\cos\omega t$	$\frac{s+k}{(s+k)^2+\omega^2}$
11.	$t\sin\omega t$	$\frac{2\omega s}{(s^2+\omega^2)^2}$

Chapter 4: Interrelation of parameters

	z	y	h	g	$ABCD$	$abcd$
z	$\begin{matrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{matrix}$	$\begin{matrix} \frac{y_{22}}{\Delta y} & \frac{-y_{12}}{\Delta y} \\ \frac{-y_{21}}{\Delta y} & \frac{y_{11}}{\Delta y} \end{matrix}$	$\begin{matrix} \frac{\Delta h}{h_{22}} & \frac{h_{12}}{h_{22}} \\ \frac{-h_{21}}{h_{22}} & \frac{1}{h_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{11}} & \frac{-g_{12}}{g_{11}} \\ \frac{g_{21}}{g_{11}} & \frac{\Delta g}{g_{11}} \end{matrix}$	$\begin{matrix} \frac{A}{C} & \frac{\Delta a}{C} \\ \frac{1}{C} & \frac{D}{C} \end{matrix}$	$\begin{matrix} \frac{d}{c} & \frac{1}{c} \\ \frac{\Delta b}{c} & \frac{a}{c} \end{matrix}$
y	$\begin{matrix} \frac{z_{22}}{\Delta z} & \frac{-z_{12}}{\Delta z} \\ \frac{-z_{21}}{\Delta z} & \frac{z_{11}}{\Delta z} \end{matrix}$	$\begin{matrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{matrix}$	$\begin{matrix} \frac{1}{h_{11}} & \frac{-h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta h}{h_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta g}{g_{22}} & \frac{g_{12}}{g_{22}} \\ \frac{-g_{21}}{g_{22}} & \frac{1}{g_{22}} \end{matrix}$	$\begin{matrix} \frac{D}{B} & \frac{-\Delta a}{B} \\ \frac{-1}{B} & \frac{A}{B} \end{matrix}$	$\begin{matrix} \frac{a}{b} & \frac{-1}{b} \\ \frac{-\Delta b}{b} & \frac{d}{b} \end{matrix}$
h	$\begin{matrix} \frac{\Delta z}{z_{22}} & \frac{z_{12}}{z_{22}} \\ \frac{-z_{21}}{z_{22}} & \frac{1}{z_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{y_{11}} & \frac{-y_{12}}{y_{11}} \\ \frac{y_{21}}{y_{11}} & \frac{\Delta y}{y_{11}} \end{matrix}$	$\begin{matrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{matrix}$	$\begin{matrix} \frac{g_{22}}{\Delta g} & \frac{-g_{12}}{\Delta g} \\ \frac{-g_{21}}{\Delta g} & \frac{g_{11}}{\Delta g} \end{matrix}$	$\begin{matrix} \frac{B}{D} & \frac{\Delta a}{D} \\ \frac{-1}{D} & \frac{C}{D} \end{matrix}$	$\begin{matrix} \frac{b}{a} & \frac{1}{a} \\ \frac{-\Delta b}{a} & \frac{c}{a} \end{matrix}$
g	$\begin{matrix} \frac{1}{z_{11}} & \frac{-z_{12}}{z_{11}} \\ \frac{z_{21}}{z_{11}} & \frac{\Delta z}{z_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta y}{y_{22}} & \frac{y_{12}}{y_{22}} \\ \frac{-y_{21}}{y_{22}} & \frac{1}{y_{22}} \end{matrix}$	$\begin{matrix} \frac{h_{22}}{\Delta h} & \frac{-h_{12}}{\Delta h} \\ \frac{-h_{21}}{\Delta h} & \frac{h_{11}}{\Delta h} \end{matrix}$	$\begin{matrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{matrix}$	$\begin{matrix} \frac{C}{A} & \frac{-\Delta a}{A} \\ \frac{1}{A} & \frac{B}{A} \end{matrix}$	$\begin{matrix} \frac{c}{d} & \frac{-1}{d} \\ \frac{\Delta b}{d} & \frac{b}{d} \end{matrix}$
A B C D	$\begin{matrix} \frac{z_{11}}{z_{21}} & \frac{\Delta z}{z_{21}} \\ \frac{1}{z_{21}} & \frac{z_{22}}{z_{21}} \end{matrix}$	$\begin{matrix} \frac{-y_{22}}{y_{21}} & \frac{-1}{y_{21}} \\ \frac{-\Delta y}{y_{21}} & \frac{-y_{11}}{y_{21}} \end{matrix}$	$\begin{matrix} \frac{-\Delta h}{h_{21}} & \frac{-h_{11}}{h_{21}} \\ \frac{-h_{22}}{h_{21}} & \frac{-1}{h_{21}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{21}} & \frac{g_{22}}{g_{21}} \\ \frac{g_{11}}{g_{21}} & \frac{\Delta g}{g_{21}} \end{matrix}$	$\begin{matrix} A & B \\ C & D \end{matrix}$	$\begin{matrix} \frac{d}{\Delta b} & \frac{b}{\Delta b} \\ \frac{c}{\Delta b} & \frac{a}{\Delta b} \end{matrix}$
a b c d	$\begin{matrix} \frac{z_{22}}{z_{12}} & \frac{\Delta z}{z_{12}} \\ \frac{1}{z_{12}} & \frac{z_{11}}{z_{12}} \end{matrix}$	$\begin{matrix} \frac{-y_{11}}{y_{12}} & \frac{-1}{y_{12}} \\ \frac{-\Delta y}{y_{12}} & \frac{-y_{22}}{y_{12}} \end{matrix}$	$\begin{matrix} \frac{1}{h_{12}} & \frac{h_{11}}{h_{12}} \\ \frac{h_{22}}{h_{12}} & \frac{\Delta h}{h_{12}} \end{matrix}$	$\begin{matrix} \frac{-\Delta g}{g_{12}} & \frac{-g_{22}}{g_{12}} \\ \frac{-g_{11}}{g_{12}} & \frac{-1}{g_{12}} \end{matrix}$	$\begin{matrix} \frac{D}{\Delta a} & \frac{B}{\Delta a} \\ \frac{C}{\Delta a} & \frac{A}{\Delta a} \end{matrix}$	$\begin{matrix} a & b \\ c & d \end{matrix}$

$\Delta z = z_{11}z_{22} - z_{12}z_{21}$; $\Delta y = y_{11}y_{22} - y_{12}y_{21}$

$\Delta h = h_{11}h_{22} - h_{12}h_{21}$; $\Delta g = g_{11}g_{22} - g_{12}g_{21}$

$\Delta a = AD - BC$; $\Delta b = ad - bc$

Chapter 7: Polynomial functions of $C_n(\omega)$ of a low-pass Chebyshev filter

Order n	Polynomial $C_n(\omega)$
0	1
1	ω
2	$2\omega^2 - 1$
3	$4\omega^3 - 3\omega$
4	$8\omega^4 - 8\omega^2 + 1$
5	$16\omega^5 - 20\omega^3 + 5\omega$
6	$32\omega^6 - 48\omega^4 + 18\omega^2 - 1$
7	$64\omega^7 - 112\omega^5 + 56\omega^3 - 7\omega$

End of paper.